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IMPACT OF IN-CHANNEL ORGANIC DEBRIS ON CHANNEL GEOMORPHOLOGY AND IN-CHANNEL STRUCTURES

First Quarterly Report to the US Army Corps of Engineers

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Administrative Developments

Mr Wallerstein has begun a one year contract to examine the impact of in-channel woody debris on channel geomorphology and run-of-the-river structures. Methods will be developed to predict and alleviate the most frequently caused problems.

A masters student, Peter Cheesman, from Nottingham University has been contracted for five months to develop a GIS front end to the debris management support system that is currently being developed.

Logistics and Travel

Mr Cheesman accompanied Mr Wallerstein on a 1 month field trip to the USA from 18th May to 15th June 1995. Two weeks were spent re-surveying the debris jams monitoring sites, and two week spent obtaining and reformatting data for the GIS. Prof. Thorne and Dr Peter Downs (University of Nottingham, co-supervisor of Mr Wallerstein's doctoral studies) visited Mississippi for one week to observe woody debris.

Research Progress

A Debris management program, written in C++, has been coded and tested. The program supplies debris management support information based upon the input channel parameters, geomorphic relationships and engineering predictors developed through this research. The program predicts the potential for scour at bridge piers due to debris build-up. The executable PC program is now available on disk. A user support manual, with a test data set, has also been written. This program will be modified as processes and better understood relationships are developed further and as the program is integrated with the GIS data input interface.

Data from the June 1995 debris survey are currently being processed and compared to the January 1995 and June 1994 data. The geomorphological survey data are also being compiled and entered into the database. Data have also been collected from bridge piers experiencing scour at sites within the DEC monitoring reaches in order to test and calibrate the pier scour model. The working hypotheses and theoretical relationships already developed to describe debris input, residence times and output from the channel network which will be tested using the semi-annual survey information are as follows:

1) Debris Input Distribution

There are two components to debris input to the channel; spatially random and spatially probabilistic.

a) Spatially random : Inputs due to tree death, leaf/litter fall, ice loading, beaver activity and windthrow.

b) Spatially Probibalistic : Inputs due to tree topple through:

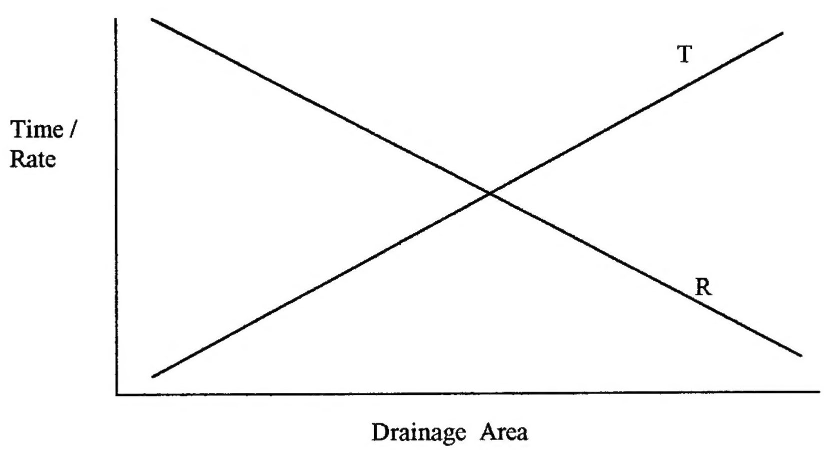
i) Bank erosion in actively meandering stable channels.

ii) Channel instability through degradation which leads to bank failure in oversteepened zones.

2) Debris spatial residence times

As drainage basin area increases, with distance downstream in the fluvial system, so does discharge and average channel width. Woody debris transport rate is, therefore, also likely to increase downstream (see Figure 1).

Figure 1. Schematic plot of Debris Residence Time versus Basin Area.



R = Residence time of debris at any particular location in the channel network.

T = Transport rate of debris through the network.

These trends also reflect the operation of debris jams in a particular reach. The total volume of debris present in a channel reach may well increase downstream, but is more mobile and is routed out of the system during high flows. Owing to the larger size of downstream channels and greater mobility of debris, coherent jams are unable to form. The rate at which debris moves through a particular reach will increase as flow competence increases. Transport capacity will also increase.

Residence time and transport rate will also determine the extent to which particular debris jams are effective in modifying the morphology and stability of the channel reach in which they are located.

3) <u>Debris Output Rates</u>

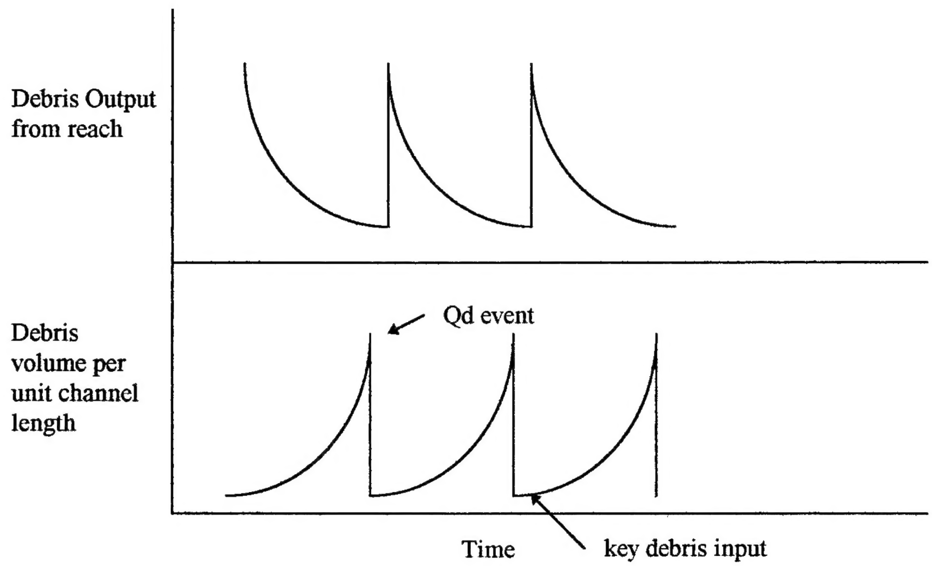
The rate of debris output from upland streams is an important variable for debris management in larger water ways where debris may be a problem at locks, dams, bridges and weirs. Output of debris from a catchment will depend upon the occurrence of flows capable of removing upstream debris jam obstructions and transporting debris into the navigation reach. Low flows are likely to transport smaller debris material which may be trapped by more coherent debris jams so that the jams are built up over time. High, in-bank flows will, in larger catchments, have the power to remove coherent jams and flush a large amount of debris out of the headwater system, into the downstream reaches. High flows will also cause bank erosion, and trigger bank mass failures particularly during and after the flow has receded (due to bank saturation), which will cause the input of another set of "Key-debris" against which new jams can form. Receding overbank flows will also transport woody debris to the main channel if the flow returns through wooded floodplain, however, large potential "Key-debris" is less likely to be floated into the channel network because it has a greater probability of being "strained out" by the standing floodplain vegetation.

It is important to note that debris volume build-up is not linear because jams become more structured and less permeable over time, so that their trapping efficiency increases. Conversely, debris output from a reach will decrease over time until the next jam breaking flood event occurs (see Figure 2).

It is therefore necessary to define a dominant discharge for jam removal (Qd) and its return period with respect to major debris flushing in order to develop an efficient, cost

effective management strategy. (For example, advising structure inspection for debris build-up with a frequency higher than the expected Qd return period).

Figure 2 : Time distributions of debris storage and flushing in small upland catchments.



Data Analysis

It has becoming apparent from the survey data collected to date that the majority of debris jams found in June 1994 are still intact in June 1995, despite a number of high flow events in the intervening period. Debris jams in small catchments (less than 50 square miles) appear to be stable features, at least over this time scale. Jams are rare in channels with catchment areas greater than this as even "key-debris" such as whole mature trees can be transported by the higher discharges in the larger channels. It appears therefore that there is a limiting catchment size (channel width) from with larger debris is made available to downstream areas. Identification of this threshold drainage area and channel size has important management implications for controlling

debris at “run-of-the-river” structures such as bridges, locks, weirs and dams, because managing woody debris through riparian vegetation management could be far more cost effective than removing it from structures. It is also becoming apparent that the input of debris from the outside of actively migrating meander bends from both stable and unstable channels is significant, as a large proportion of the total number of jams surveyed can be found at the apices of bends, while significant debris input in straight channels is limited to those channels which are highly unstable (for example Nolehoe creek). It is also evident that meander apices are a preferential site for deposition of debris which has been floated from upstream. This is likely to be due to the propelling of debris to the outside of bends by centrifugal force and outward flowing secondary currents at the water surface. At the outside of the bend, debris then becomes snagged in vegetation or is pinned to the bank and deposited at its base as high flows recede.

Plans for the next quarter

* To extend the literature review to assessment of debris management practises at run of river structures in British and European River.

* Complete the GIS database and integrate it with the debris management support program. The management program will also be further updated and improved.

* June 1995 survey and geomorphic data will be added to the database, plotted and analysed.

* A proposal will be submitted to the US Army Corps of Engineers for a 3-4 month, US based, research effort, by Mr Wallerstein, to asses the impact of debris at run-of-river structures in order to develop a coherent management framework and improved set of design criteria for future projects.

* An abstract has been accepted for the Sixth Federal Interagency Sedimentation Conference to be held in Las Vegas, March 1996. This will allow "market testing" of the management program with a group of experienced, practical engineers and river managers which is a very important step in the development of any product intended for use in the real world. The paper for this conference will be written and submitted by September 8th 1995.